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Development and Characterization of Curcumin Loaded Emulgel for Topical use

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ABSTRACT

This study aimed to formulate and evaluate a curcumin emulgel for the treatment of arthritis. Curcumin, known for its potent and antioxidant properties, was incorporated into an emulgel to enhance its solubility, stability, and topical delivery. The emulgel was prepared using a combination of emulsion and gel systems and characterized for physical appearance, pH, spredability, viscosity, and drug content. The optimized formulation showed appropriate pH, high spredability, and adequate viscosity, ensuring ease of application and sustained release. In vitro release studies demonstrated a controlled drug release profile. These results suggest that the curcumin emulgel offers a promising therapeutic approach for arthritis, combining the benefits of topical application with enhanced curcumin delivery. Further clinical trials are recommended to validate its efficacy and safety in human subjects.

Keywords: Curcumin; Antioxidant; Emulgel; Topical delivery; Inflammation; Spredability; Viscosity; Optimized formulation; Drug content.

1. Introduction

Different routes of administrations were used in past years to cure any illness, routes that were used were sublingual, oral, rectal, topical, parenteral, inhalation, etc. When a person has cutaneous disorders like acne, eczema, psoriasis, etc. then topical delivery is preferred, which is the application of the required drug to the skin. This route of administration has many years of history, but new methods and technologies are being investigated and developed for better patient compliance [1],[4]. The topical route of administration is the best option for cutaneous purposes as the skin is the most accessible organ and facilitates the delivery of drugs with better efficacy when compared to the other routes of administration. Topical preparations are used most commonly locally for localized effects at the site of their application [1]-[5].

1.1. Study Objectives

The following are the main objectives of this study: (1) Formulate a gel containing curcumin extract as the active ingredient. (2) Optimize the formulation parameters to enhance the stability. (3) Formulating the pH of the gel. (4) Evaluate the viscosity of the gel. (5) Determining the spredability and extrudability of the gel. (6) In Vitro drug release studies. (7) DCS study and FTIR.

2. Experimental work

2.1. Study of drug-excipient interactions

Using a FT-IR spectrophotometer, the drug and its excipients were examined. By interpreting I.R. spectrums, the drug's interaction with the excipients was found [6],[7].

2.2. DSC Study

The test was performed “to determine the drug's purity and compatibility with the emulgel formulation and the DSC measurements were carried out using a thermal analyzer and a differential scanning calorimeter (DSC 822 c,

Mettler Toledo) here, 2 mg of tretinoin was placed in a sealed aluminium pan and heated at a scanning rate of 50 ºC/min from 20 ºC to 250 ºC under a nitrogen flow of 20 ml/min". As a guide, an empty aluminium pan was employed [4],[9].

2.3. Solubility Studies

The spontaneous interaction of two or more substance to form homogeneous molecular dispersion is called as solubility.

2.3.1. Method of preparation

The production of emulgel consists of three key steps:

Step 1: Preparation of the emulsion, which might be W/O or O/W.

Step 2: Creating a gel basis by mixing water and gelling chemicals continuously while adjusting their pH.

Step 3: Emulsion incorporation into gel base while heating and stirring continuously. Emulgel preparation is a relatively easy and economical process. It incorporates the medication as needed. The gel base must next be formed. This is done by combining filtered water with a solvent fixing agent, or soluble component, and heating it to 70 degrees Celsius. Additionally, it contains emulsifying agents such as tween.

The oil phase is taken into account after the aqueous phase is ready. Dissolving surfactants like spans is how it is made. Once a hydrophobic medication is added, it is heated to the same temperature. Currently, the gel is made by evenly distributing the polymer in filtered water while maintaining a moderate pace of mixing. At this moment, the pH is adjusted between 6 and 6.5. Preservatives were introduced in the aqueous phase as the final step. After heating the oil and aqueous phases to 70 to 80 degrees Celsius, respectively, the oily phase was introduced to the aqueous phase and stirred continuously. Ensure that it has reached room temperature. The emulsion is added to the gel base with a ratio of 1:1 for the formation of emulgel [1]-[5].

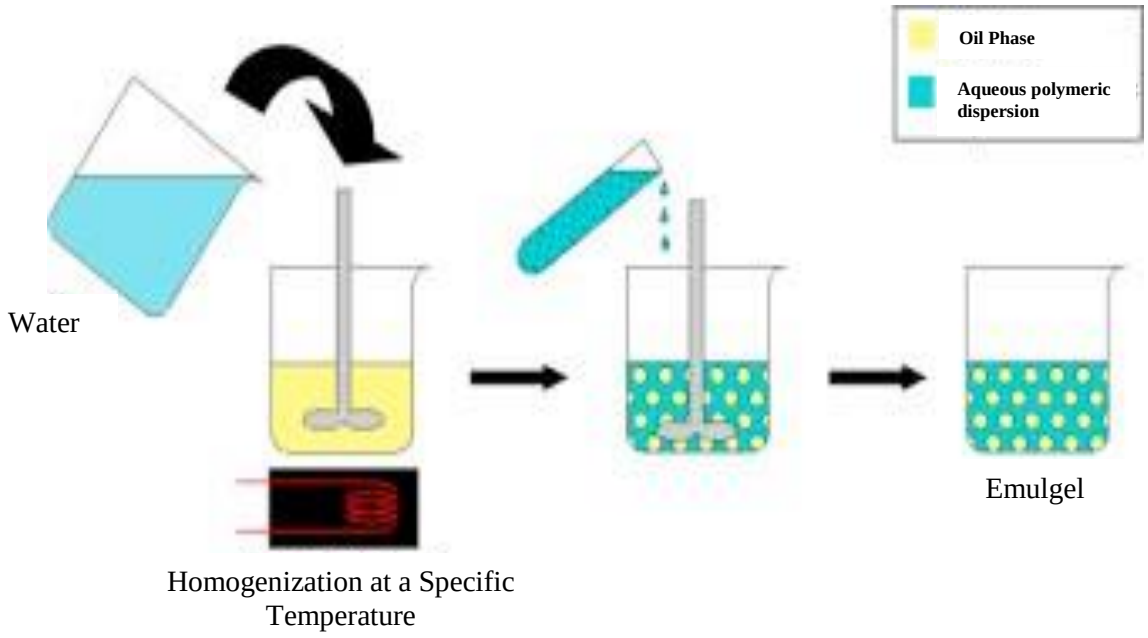

Figure 1. Method of preparation [2]

Table 1. Chemical use

S. No.	Chemical Name	Use (w/w)		
		F- 01	F- 02	F- 03
01	Extract	0.01 g	0.01 g	0.01 g
02	Light liquid paraffin	10 ml	5 ml	5 ml
03	Propyl Glycol	5 ml	5 ml	5 ml
04	Propyl Paraben	0.2 g	0.2 g	0.2 g
05	Carbopol – 934	1 g	1 g	1 g
06	Tween 80	0.2 ml	2 ml	15 ml
07	Spam 80	25 ml	25 ml	15 ml
08	Ethanol	5 ml	5 ml	5 ml
09	Tri ethanolamine	qs	qs	qs

3. Characterization

3.1. Physical Properties

Physicochemical parameters such as “colour, odour, and consistency were examined in the Tretinoin-containing emulgel formulations”.

3.2. Drug Release Studies [6-8]

A modified “Franz diffusion (FD) cell was used in the in-vitro drug release tests, firstly the formulation was applied to a dialysis membrane sandwiched between the donor and receptor compartments of the Franz diffusion cell” (which had previously been soaked in phosphate buffer pH 7.4 for 24 hours). By putting the cell in the water bath, the temperature was kept at 370.2 °C. This “entire assembly was placed on a magnetic stirrer, and the solution was continually stirred at 50 rpm using a magnetic bead, after adequate dilutions, the samples (2 ml) were withdrawn at a sufficient time interval and examined for drug content using a UV visible spectrophotometer at 425 nm”. The percent drug release was estimated using UV Spectroscopy at 425 nm.

3.3. DSC Study

The test was performed “to determine the drug's purity and compatibility with the emulgel formulation and the DSC measurements were carried out using a thermal analyzer and a differential scanning calorimeter (DSC 822c, Mettler Toledo) here, 2 mg of tretinoin was placed in a sealed aluminium pan and heated at a scanning rate of 50 ºC /min from 20 ºC to 250 ºC under a nitrogen flow of 20 ml/min”. As a guide, an empty aluminium pan was employed.

3.4. pH Test

We measured the pH of the created emulgel mixtures using a digital pH metre. 100 millilitres of distilled water were used to dissolve 1 gramme of emulgel, and the mixture was let to sit for 2 hours. 3 measurements of each formulation's pH were taken, and the average findings were calculated [3],[5],[8],[10].

3.5. Rheological Study

The "viscosity was measured with a cone and plate viscometer with spindle 7 (Brookfield rheometer) and the viscosity-to-be-measured formulation was placed in a beaker and allowed to settle for 30 minutes, before the measurement, the temperature was set to the assay temperature (250 °C) and the spindle was lowered perpendicularly into the centre of the emulgel, making sure it did not touch the jar's bottom, and rotated at 50 rpm for 10 minutes.

Further, the spindle was moved up and down, resulting in viscosities at various locations along the path". The viscosity of the gel was calculated as the average of values made over a 10-minute period.

3.6. Spredability

A pulley is fastened to one end of a wooden block that makes up the device. Using the 'Slip' and 'Drag' characteristics of the emulgel, the spreading coefficient was computed. On the wood block, a glass slide was set in the ground. On this ground slide, there was an extra 1 g of emulgel.

Between this one and the emulgel was a second glass slide that was the same size as the fixed ground slide. The hook is included with the second glass slide. To remove air from the area between the two slides and produce a uniform layer of emulgel, a 100 g weight was placed on top of them for five minutes.

The measured weight (35 g) was dropped into the pan fastened to the pulley using a hook. "Time in seconds it takes for two slides to separate" from the emulgel and be put in between them under the influence of a specific force. The spredability improves as the time it takes to separate two slides decreases. The formula is used to calculate it, in which "S = ML/T (where M = wt tied to upper slide, L = length of glass slides, and T = time taken to separate the slides)" [11],[12].

3.7. Extrudability

It's a common "empirical test to determine how much force is required to extrude a material tube and the method was used to determine the amount of applied shear in the rheogram region corresponding to a shear rate greater than the yield value and exhibiting plug flow and finally the extrudability of the formulation from the packed material was examined after the emulgels were loaded into crimped, collapsible tubes" [11],[12].

3.8. Stability Study

Three groups of the prepared Transferosomel gels were formed. These three Transferosomel gel formulation groups were placed within collapsible aluminum tubes and kept at: Temperature of the room (25 °C), 40 °C, and 4 °C.

For three months, the Transferosomel gel formulation was kept in storage. For a duration of three months, samples were taken out each month and their drug content evaluated. They were assessed for physical parameters and product integrity at the conclusion of the third month.

- **Physical evaluation**

The physical factors that were taken into account for the assessment were the product's nature, extrudability, pH, viscosity, leak, and phase separation [11].

4. Result and Discussion

4.1. Preformulation study

4.1.1. Study of drug-excipient interactions-

Using a FT-I.R spectrophotometer, the drug and its excipients were examined. By interpreting I.R. spectrums, the drug's interaction with the excipients was found.

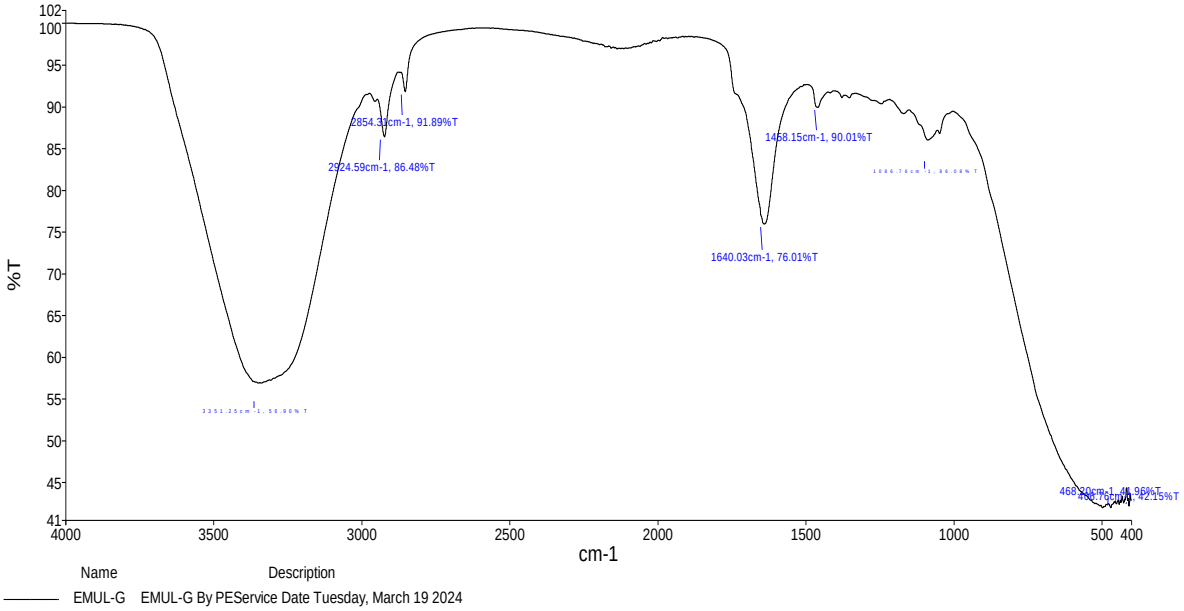

Figure 2. FT-IR of Emulgel

Table 2. FT-IR interpretation of Emulgel

S. No.	Peak Position	Group
01	3351.25	O-H stretching, N-H stretching
02	2854.31	O-H stretching, N-H stretching, C-H stretching
03	2924.59	O-H stretching, N-H stretching, C-H stretching
04	1640.03	C=O stretching, C=N stretching, C=C stretching, N-H bending
05	1458.15	C-H bending
06	1086.76	C-F stretching, C-N stretching, C-O stretching

4.1.2. DSC Study

The test was performed "to determine the drug's purity and compatibility with the emulgel formulation and the DSC measurements were carried out using a thermal analyzer and a differential scanning calorimeter (DSC 822 c, Mettler Toledo) here, 2 mg of tretinoin was placed in a sealed aluminium pan and heated at a scanning rate of 50 ºC /min from 20 ºC to 250 ºC under a nitrogen flow of 20 ml/min". As a guide, an empty aluminium pan was employed.

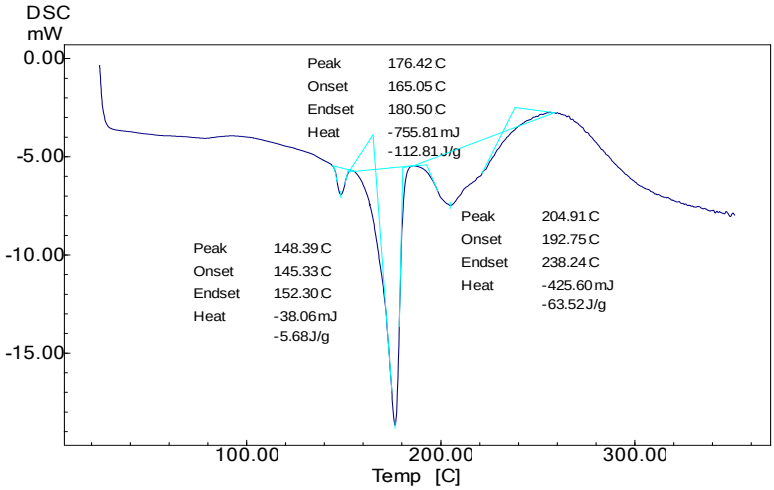

Figure 3. DSC of Curcumin

4.1.3. Solubility Studies

The spontaneous interaction of two or more substance to form homogeneous molecular dispersion is called as solubility.

Table 3. Solubility

S.No.	Chemical Name	Result
01	Methanol	+++
02	Ethanol	++++
03	Ether	++++

4.2. Evaluation of Emulgel

4.2.1. Physical study

The physical properties (colour, appearance, homogeneity, and phase separation).

4.2.2. Measurement of pH

The pH of developed emulgel formulations was determined using a digital pH meter, first, 1 gm of emulgel was dissolved in 100 ml distilled water and kept aside for two hours and the measurement of pH of each formulation was done in triplicate.

Table 4. Measurement of pH

S.No.	Formulation	pH
01	Formulation-1	6.5
02	Formulation-2	6.7
03	Formulation-3	6.8

4.2.3. Rheological study

Using a cone and plate viscometer with spindle 5

Table 5. Rheological study

S.No.	Formulation	Viscosity in cps
01	Formulation-1	48,000
02	Formulation-2	48,500
03	Formulation-3	46,994

4.2.4. Extrudability

The extrudability of the gel formulations were checked as per the procedure, extrudability of gels was excellent. It is shown in Table no. 6.

Table 6. Extrudability Test

S. No.	Formulation	Extrudability
01	Formulation-1	+++
02	Formulation-2	+++
03	Formulation-3	+++

4.2.5. Spredability

Table 7. Spredability Test

S. No.	Formulation	Result
01	Formulation-01	20±31
02	Formulation-02	25±31
03	Formulation-03	22±31

4.2.6. In Vitro Drug Release

Diffusion Study

Table 8. Drug Release Test

S. No.	Time in (hrs)	Absorbance at 425 nm
1	0	0
2	0.25	0.627
3	0.5	0.648
4	0.75	0.656
5	1	0.659
6	1.5	0.662

7	2	0.668
8	2.5	0.669
9	3	0.671
10	4	0.674
11	5	0.678
12	6	0.686
13	7	0.688
14	8	0.689
15	9	0.694
16	10	0.696
17	11	0.698
18	12	0.699
19	14	0.703
20	16	0.709
21	18	0.715
22	20	0.717
23	22	0.718
24	24	0.718

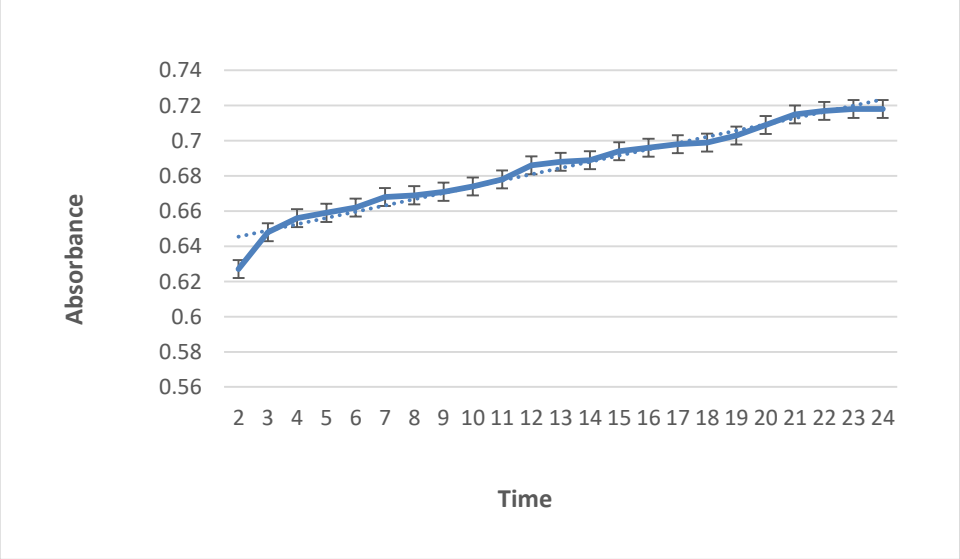

Figure 4. Drug Release Test

4.2.7. Stability Study

The stability studies of formulation were carried out at refrigeration temperature (4 ℃), Room temperature and 40 °C. Physical evaluation of prepared formulation shown in the Table no. 9.

Table 9. Stability Study

Parameter	Room Temperature (25 ℃)	40 ^{0}C	4 ^{0}C
Visual Appearance			
• Initial	Yellow colour gel	Yellow colour gel	Yellow colour gel
• 1 month	Yellow colour gel	Yellow colour gel	Yellow colour gel
• 2 month	Yellow colour gel	yellow colour gel	Yellow colour gel
• 3 month	Yellow colour gel	Yellow colour gel	Yellow colour gel
pH			
• Initial	6.7	6.7	6.7
• 1 month	6.7	6.7	6.7
• 2 month	6.8	6.8	6.8
• 3 month	6.8	6.8	6.8
Viscosity			
• Initial	48,500	48,500	48,500
• 1 month	48,500	48,500	48,500
• 2 month	48,497	48,497	48,500
• 3 month	48,495	48,495	48,497
Extrudability			
• Initial	Satisfactory	Satisfactory	Satisfactory
• 1 month	Satisfactory	Satisfactory	Satisfactory
• 2 month	Satisfactory	Satisfactory	Satisfactory
• 3 month	Satisfactory	Satisfactory	Satisfactory
Phase Separation			
• Initial	Not found	Not found	Not found
• 1 month	Not found	Not found	Not found
• 2 month	Not found	Not found	Not found
• 3 month	Not found	Not found	Not found
Texture			
• Initial	Smooth	Smooth	Smooth
• 1 month	Smooth	Smooth	Smooth
• 2 month	Smooth	Smooth	Smooth
• 3 month	Smooth	Smooth	Smooth

5. Conclusion

This study successfully formulated and evaluated a curcumin emulgel for the treatment of arthritis. The optimized emulgel demonstrated appropriate pH, high spreadability, and suitable viscosity, which are crucial for ease of application and sustained release. In vitro release studies confirmed a controlled drug release profile. These results suggest that the curcumin emulgel offers a promising and effective therapeutic approach for arthritis, enhancing the delivery and efficacy of curcumin through topical application. Further clinical trials are recommended to validate these findings and ensure the emulgel's efficacy and safety in human subjects.

6. Summary

The study focused on formulating and evaluating a curcumin emulgel for treating arthritis. Curcumin, with its strong and antioxidant properties, was incorporated into an emulgel to improve its solubility, stability, and topical delivery. The emulgel was prepared by combining emulsion and gel systems and characterized for various parameters, including physical appearance, pH, spreadability, viscosity, and drug content. The optimized formulation exhibited suitable pH, high spreadability, and appropriate viscosity, facilitating ease of application and sustained release. In vitro release studies showed a controlled drug release profile, these findings indicate that the curcumin emulgel is a promising therapeutic option for arthritis, offering the benefits of topical application with enhanced curcumin delivery. Further clinical trials are recommended to confirm its efficacy and safety in human subjects.

7. Future Prospects of Curcumin Loaded Emulgel for Topical Use

Enhanced Skin Penetration and Bioavailability

Future research could focus on further optimizing the formulation to enhance the skin penetration and bioavailability of curcumin. Innovations in emulgel technology could improve curcumin's solubility and stability, leading to more effective topical treatments.

Broader Therapeutic Applications

Given curcumin's well-documented anti-inflammatory, antioxidant, and antimicrobial properties, future studies could explore its application in treating a wider range of skin disorders. This includes conditions such as eczema, psoriasis, and bacterial infections, potentially expanding its therapeutic reach.

Clinical Trials and Regulatory Approval

Rigorous clinical trials are essential to establish the safety and efficacy of curcumin-loaded emulgel in human subjects. These trials would help in understanding the optimal dosing, potential side effects, and long-term effects, which are crucial for regulatory approval and commercial viability.

Personalized Skincare Solutions

Advances in personalized medicine could lead to the development of customized curcumin emulgels tailored to individual skin types and conditions. By adjusting concentrations and incorporating additional beneficial compounds, personalized treatments could offer enhanced efficacy and patient satisfaction.

Commercialization and Market Expansion

Successful clinical outcomes could pave the way for the commercialization of curcumin-loaded emulgel products. The growing consumer preference for natural and effective skincare solutions suggests a promising market potential. Products could be developed for anti-aging, acne treatment, and general skincare, capitalizing on curcumin's natural therapeutic properties.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis and manuscript writing equally.

Availability of data and material

All data pertaining to the research is kept in good custody by the authors.

References

[1] Alaaeldin, E., Abou-Taleb, H.A., & Mohamad, S.A. (2021). Topical nano-vesicular spanlastics of celecoxib: enhanced anti-inflammatory effect and down-regulation of tnf-alpha, nf-small ka, cyrillicb and cox-2 in complete freund’s adjuvant-induced arthritis model in rats. Int J Nanomed., 16: 133–45.

[2] Alamri, R.D., Elmeligy, M.A., & Albalawi, G.A. (2021). Leflunomide an immunomodulator with antineoplastic and antiviral potentials but drug-induced liver injury: a comprehensive review. Int Immunopharmacol., 93: 107398.

[3] Hasan, S., Bhandari, S., Sharma, A., & Garg, P. (2021). Emulgel: A Review. Asian J. Pharm. Res., 11(4): 263–268. doi: 10.52711/2231-5691.2021.00047.

[4] Cao, J., Su, J., & An, M. (2021). Novel dek-targeting aptamer delivered by a hydrogel microneedle attenuates collagen-induced arthritis. Mol Pharm., 18: 305–16.

[5] Deng, C., Zhang, Q., & He, P. (2021). Targeted apoptosis of macrophages and osteoclasts in arthritic joints is effective against advanced inflame matory arthritis. Nat Commun., 12: 2174.

[6] Dudhipala, N., Phasha Mohammed, R., & Adel Ali Youssef, A. (2020). Effect of lipid and edge activator concentration on development of aceclofenac-loaded transfersomes gel for transdermal application: in vitro and ex vivo skin permeation. Drug Dev Ind Pharm., 46: 1334–44.

[7] Liu, C., Guan, Y., & Tian, Q. (2019). Transdermal enhancement strategy of ketoprofen and teriflunomide: the effect of enhanced drug-drug intermolecular interaction by permeation enhancer on drug release of compound transdermal patch. Int J Pharm., 572: 118800.

[8] Liu, W., Zhang, Y., & Zhu, W. (2018). Sinomenine inhibits the progression of rheumatoid arthritis by regulating the secretion of inflammatory cytokines and monocyte/macrophage subsets. Front Immunol., 9: 2228.

[9] Ma, G., & Wu, C. (2017). Microneedle, bio-microneedle and bio-inspired microneedle: a review. J Control Release, 251: 11–23.

[10] McAlister, E., Dutton, B., & Vora, L.K. (2021). Directly compressed tablets: a novel drug- containing reservoir combined with hydrogel-forming microneedle arrays for transdermal drug delivery. Adv Healthc Mater., 10: e2001256.

[11] Tiwari, P., Yadav, R., Kushwah, D., Dwivedi, D., Sagar, S., Bansal, A., Pandey, S., Rajpoot, J., & Chaudhuri, A. (2024). Formulation and Characterization of herbal Emulgel by using four Tradesman herb *Tamarindus indica, Achyranthes aspera, Nyctanthes arbor-tristis, Syzygium cumini*. Asian Journal of Applied Science and Technology, 8(2): 115–127.

[12] Tiwari, P., Alagusundaram, M., Mishra, N., Bhattacharya, V., & Keshri, P. (2024). Formulation and Evaluation of *Tamarindus indica* Extract Loaded Transfersomal Gel for Anti-inflammatory Effect. Asian Journal of Applied Science and Technology, 8 (2): 138–155.